BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

LAWRENCE MIIKE
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
ENVIRONMENTAL MANAGEMENT DIVISION
SOLID AND HAZARDOUS WASTE BRANCH
919 ALA MOANA BLVD., #212
HONOLULU, HAWAII 96814

In reply, please refer to:
EMD/SHW

Monitored Natural Attenuation for Dissolved Phase Petroleum Hydrocarbons in Groundwater at Concentrations above Hawaii Department of Health Tier 1 Action Levels

TO ALL INTERESTED PARTIES:

The Hawaii Department of Health's Solid and Hazardous Waste Branch, Underground Storage Tank Section, is issuing this policy regarding the use of monitored natural attenuation as a potential cleanup remedy for petroleum hydrocarbons dissolved in groundwater.

This policy describes the information required by the Hawaii Department of Health's Solid and Hazardous Waste Branch, Underground Storage Tank Section in support of monitored natural attenuation as a groundwater cleanup remedy. The use of monitored natural attenuation as a cleanup remedy may be appropriate at certain petroleum release sites. To justify the use of monitored natural attenuation (MNA) as a site cleanup remedy, an adequate demonstration of its occurrence, its effectiveness as a suitable remedy, and its protectiveness of receptors must be made. The DOH will henceforth evaluate all existing and proposed remedies involving natural attenuation of hydrocarbons in groundwater for compatibility with the six criteria described in the attached policy.

This new policy will provide additional flexibility in consideration of cost effective groundwater cleanup options (i.e., MNA as either a stand alone remedy or in combination with active remedial measures) while assuring that the use of monitored natural attenuation is protective of human health and the environment.

Please bring this policy update to attention of anyone you know who may have an interest in this matter. Should you have any questions regarding this policy, please contact the Underground Storage Tank Section at (808) 586-4226.

Sincerely,

STEVEN Y.K. CHANG, P.E., MANAGER
Solid and Hazardous Waste Branch

Attachment

Monitored Natural Attenuation for Dissolved Phase Petroleum Hydrocarbons in Groundwater at Concentrations above Hawaii Department of Health Tier 1 Action Levels

The use of monitored natural attenuation as a remedy for petroleum hydrocarbon releases to groundwater has become increasingly recognized as a viable remedial cleanup option where it can be demonstrated that site conditions are appropriate for its occurrence and it is protective of receptors. The U.S. Environmental Protection Agency and many states have accepted the use of monitored natural attenuation as a cleanup remedy at numerous petroleum release sites.

Natural attenuation is considered a passive remedial approach which depends on naturally occurring processes to dissipate and degrade petroleum constituents in groundwater. Some of the natural attenuation processes in groundwater include aerobic and anaerobic biodegradation (destructive mechanisms), dispersion, volatization, and adsorption (non-destructive mechanisms). While all of the above mechanisms may play a role in the reduction of petroleum hydrocarbon concentration at a release site, the Hawaii Department of Health (DOH) considers aerobic and anaerobic biodegradation (intrinsic biodegradation) to be the most important means of natural attenuation as it results in the destruction of the contaminant. For example, petroleum related compounds such as benzene, toluene, ethylbenzene, and xylene (BTEX), which typically are the contaminants presenting the greatest risk to human health or the environment resulting from a petroleum release, may degrade over time through microbial processes to non-toxic compounds such as carbon dioxide and water. However, non-destructive natural attenuation processes reduce the concentration of contaminants in water, but do not reduce the contaminant mass. In actuality, it is expected that at any site where natural attenuation of petroleum hydrocarbons in groundwater is occurring, a combination of both destructive and non-destructive processes is taking place.

Acceptability of Monitored Natural Attenuation Remedy

The DOH believes that monitored natural attenuation of petroleum hydrocarbons dissolved in groundwater may be an acceptable remedy where an adequate demonstration of its occurrence, effectiveness as a suitable remedy, and its protectiveness of receptors can be made. Such a demonstration should include six key components: (1) a demonstration of no adverse impact on receptors; (2) source control; (3) demonstration of effectiveness; (4) performance monitoring; (5) a contingency plan; and (6) comparison to other remedial options.

The level of site characterization will generally be greater when monitored natural attenuation is proposed as a remedy. This is necessary as the contaminant behavior at the site is controlled by dynamic processes. Site characterization for monitored natural attenuation will generally require a quantitative understanding of source mass, groundwater flow, contaminant phase distribution, rates of biological

and non-biological transformation, and an understanding of how these factors vary with time.

For the reasons stated earlier about biodegradation's effectiveness through contaminant destruction, DOH would view more favorably the use of monitored natural attenuation as a cleanup remedy where it can be demonstrated that biodegradation is occurring. In general, the compounds most easily biodegraded in the subsurface are petroleum hydrocarbons. In addition, the suitability of a site for intrinsic bioremediation depends not only on the contaminant's biodegradability, but also on the site's geological and chemical characteristics. For intrinsic bioremediation, key site characteristics which favor its occurrence are consistent groundwater flow throughout the year; the presence of carbonates in the aquifer that can buffer pH changes (such as limestone or shell material); and high background concentrations of oxygen, nitrate, or other electron acceptors such as sulfate, or ferric iron.

The DOH document titled *Risk-Based Corrective Action and Decision Making at Sites with Contaminated Soil and Groundwater*, dated December 1995 and revised June 1996, discussed the acceptability of allowing certain groundwater plumes to degrade over time to concentrations less than Tier 1 action levels. The use of such a remedy would only be allowed through a demonstration that the plume would not move offsite and adversely impact downgradient drinking water wells or surface water bodies. Groundwater monitoring and in some cases fate-and-transport modeling would be required to estimate groundwater movement and contaminant degradation at such sites. This discussion of monitored natural attenuation is for the purpose of further defining DOH policy and technical requirements for petroleum release sites where natural attenuation may be considered as part of or the entire cleanup remedy.

The DOH does not view monitored natural attenuation as a presumptive or default remedy for releases of petroleum hydrocarbons, but one that may be considered along with other means of contaminant remediation when evaluating petroleum cleanup options. The advantages and disadvantages of monitored natural attenuation listed in Table 1 should be considered when evaluating monitored natural attenuation as a remedial approach.

This policy only addresses the use of monitored natural attenuation for groundwater and is not applicable to hydrocarbon contamination in soil. The reader should refer to the DOH *Technical Guidance Manual for Underground Storage Tank Closure and Release Response*, dated August 1992 and associated policy updates for guidance on cleanup of petroleum hydrocarbons in soil resulting from UST releases.

Table 1
Advantages and Disadvantages of Monitored Natural Attenuation

Advantages	Disadvantages
▸ Usually lower costs than most active remedial alternatives	▸ Not effective where constituent concentrations are high (>20,000 to 25,000 ppm)
▸ Minimal disturbance to site operations	▸ Not appropriate where site complexities preclude determination of contaminant sources and direction of movement, or prevent adequate monitoring (e.g., fractured and other complex geologic systems)
▸ May be used in conjunction with, or as a followup to other remedial measures	▸ Not suitable under certain site conditions (e.g., impacted drinking water supply)
▸ Generation of lesser volume of remediation wastes, reduced potential for cross-media transfer of contaminants, and reduced risk of human exposure to contaminated media	▸ Not appropriate for certain non-degradable compounds such as MtBE
▸ Conventional remedial technologies could pose greater risk to receptors (e.g., risk to on-site workers, releases to atmosphere, fugitive vapors, etc.)	▸ Longer period of time may be required to remediate contamination than for active remedial measures
▸ Constituents such as BTEX that typically cause the greatest risk are generally the most susceptible to biodegradation	▸ May not achieve the required cleanup levels within a reasonable length of time
	▸ Longer period of monitoring required
	▸ May not be appropriate based on the future potential use of property
	▸ May be difficult to gain public acceptance

Available Policy and Technical Guidance

Petroleum releases which have impacted groundwater above DOH Tier 1 action levels will require that remedial measures be taken to ensure that human health and the environment are protected. One purpose of this guidance is to assist owners and operators, and their consultants, who must consider remedial alternatives to address petroleum releases to groundwater. Early consideration of remedial measures will help to ensure that appropriate site characterization data is collected during the investigation phase. This would include data on certain soil, groundwater and plume characteristics that are necessary to support a monitored natural attenuation remedy that might not be collected without its consideration up front. At this time, there are several excellent references which describe the type of data to collect and the evaluation approach necessary to support monitored natural attenuation as a site remedy. Table 2 lists these recommended references. It is strongly recommended that if monitored natural attenuation is to be considered as a remedy, the above documents should be reviewed and used as technical and procedural references.

Table 2
Technical References for Monitored Natural Attenuation

Chapter IX (Natural Attenuation of Petroleum Hydrocarbons) of the U.S. EPA publication: ***How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers.*** (EPA 510-B-95-007), dated May 1995.
Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Directive Number 9200.4-17. Available at EPA Web Site **http://www.epa.gov/swerust1/directiv/9200 417.htm**
Final Standard Guide for Remediation of Groundwater by Natural Attenuation at Petroleum Release Sites, **(ASTM Designation E1943-98)** American Society for Testing and Materials. Available for purchase from ASTM Web Site **http://WWW.ASTM.COM**
Technical Protocol for Implementing Intrinsic Remediation with Long-term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Ground.water, Air Force Center for Environmental Excellence, dated November 11, 1995. Contact Brooks Air Force Base, Technology Transfer Division, Phone (210) 536-4331

In addition, the use of groundwater and vadose zone modeling may be an appropriate tool to use in support of a monitored natural attenuation remedy. The United States Environmental Protection Agency's Center for Subsurface Modeling Support, or CSMoS, provides a source of publicly available groundwater and vadose modeling software and services. Software and related information may be downloaded from their WEB page located at http://www.epa.gov/ada/csmos.html.

DOH expects that monitored natural attenuation will be most appropriate at LUST sites where it can be demonstrated that there is low potential for continued plume generation and migration. It is recommended that if monitored natural attenuation is to be considered as a remedial option, early coordination with DOH be conducted to ensure that the appropriate site data is collected and technical analyses are performed.

DOH Requirements for Demonstration of the Appropriateness of a Monitored Natural Attenuation Remedy

When monitored natural attenuation is proposed as a groundwater cleanup option to DOH, the items listed below should, at a minimum, be addressed to support the use of natural attenuation as a remedy. Figure 1 outlines the monitored natural attenuation evaluation process.

Most of the required information (groundwater contaminant concentrations, plume definition, groundwater flow, geochemical data, hydrogeological data) should be collected as part of the release response site characterization activities described in DOH's *Technical Guidance Manual for Underground Storage Tank Closure and Release Response* (TGM), dated August 1992.

For some contaminants above health protective levels (generally DOH Tier 1 concentrations) which do not readily biodegrade such as methyl tertiary-butyl ether (MTBE), the use of monitored natural attenuation may not be appropriate.

The Release Response Report should address the following six elements in the evaluation of a monitored natural attenuation remedy.

1. **Demonstration of No Adverse Impact on Receptors**

   A demonstration should be made that the attenuating plume currently does not and will not in the future adversely impact drinking water supplies, other groundwaters, surface waters, ecosystems, sediments, air or other environmental resources if monitored natural attenuation is the selected remedy. In addition, the protective measures taken to ensure that future exposures are prevented must be included in the remedy (e.g., land use controls such as deed restrictions, zoning, groundwater well placement prohibition, etc.). This may best be addressed through the preparation of an Exposure Prevention Management Plan as described in the TGM.

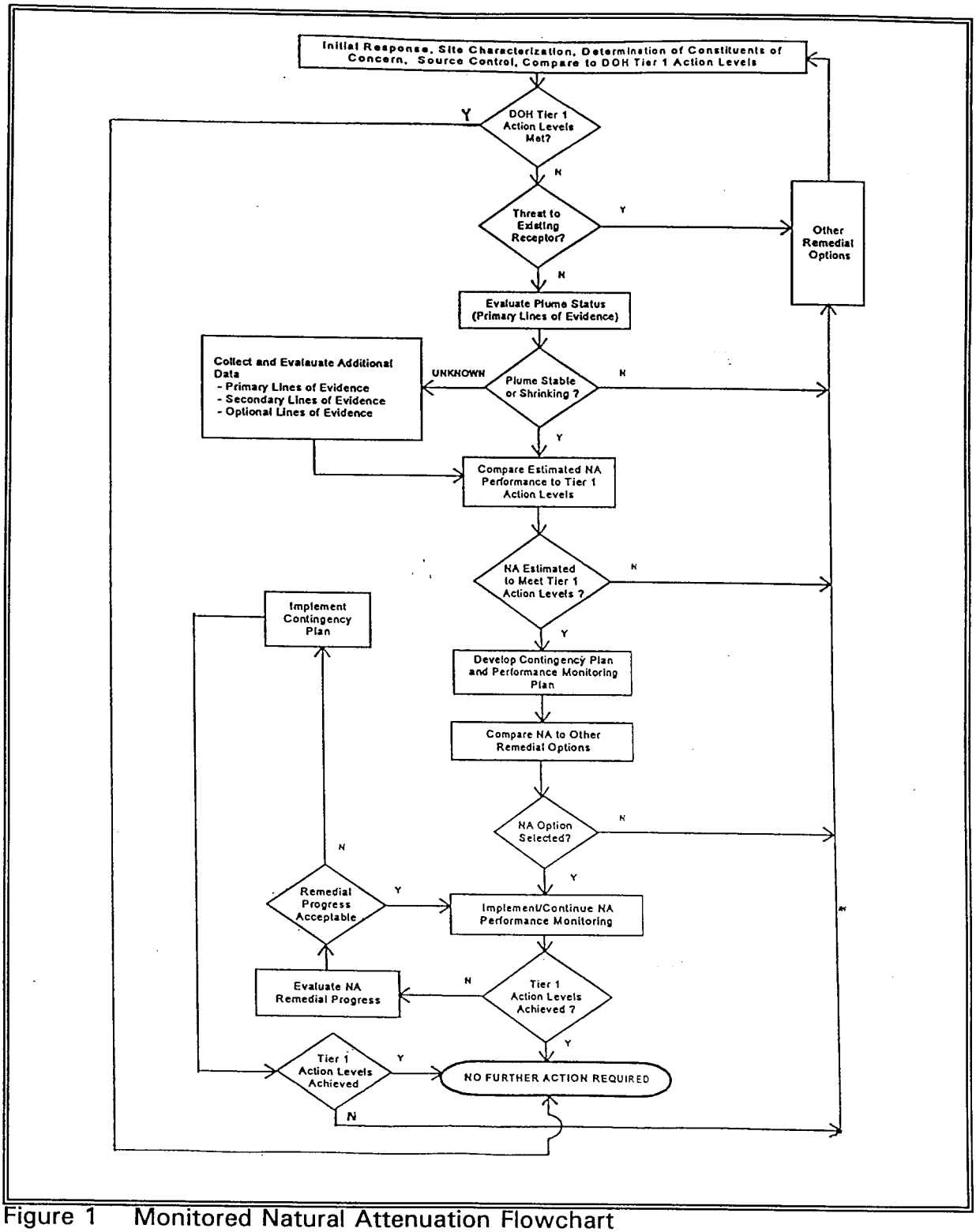

Figure 1 Monitored Natural Attenuation Flowchart

2. Source Control

The source of the contamination which has impacted groundwater should be identified, characterized and removed or controlled. Without adequate characterization and control of the source area, the long-term viability of natural attenuation is in doubt. In most cases the initial source of contamination, the UST system, has been removed or repaired. Residual highly contaminated soil which can continue to adversely impact groundwater or free product on groundwater should be actively remediated to the maximum extent practicable. Without the removal of continued sources of groundwater contamination, it is unlikely that monitored natural attenuation would be an effective remedy.

3. Demonstration of Effectiveness

A demonstration of the appropriateness of natural attention as a remedy should occur through the presentation of supporting lines of evidence. The DOH requires the use of multiple lines of evidence as described in the ASTM *Standard Guide for Remediation of Groundwater by Natural Attenuation at Petroleum Release Sites* and U.S. EPA Directive *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*.

Primary lines of evidence - Included in the primary lines of evidence are field and analytical data, which identify the type of contaminants and the size of the plume. The sampling data should be sufficient in both temporal and spatial analysis to define the plume as either shrinking or stable. For sites with sufficient historical monitoring data, the primary line of evidence may be sufficient to support natural attenuation as an acceptable remedy.

Secondary lines of evidence - Secondary lines of evidence include hydrogeologic or geochemical data which can be used to demonstrate the occurrence of natural attenuation at the site. Such additional data could include: dissolved oxygen, pH, conductivity, nitrate, sulfate, methane, carbon dioxide, oxidation/reduction potential, etc. For sites that have recently begun characterization and believe monitored natural attenuation could be a viable remedy, it may be appropriate to supplement primary lines of evidence with secondary lines of evidence. If initial groundwater monitoring data and secondary lines of evidence support the occurrence of natural attenuation as a remedy, the owner/operator should continue to monitor and collect groundwater data to support that natural attenuation is occurring through substantiation of the primary line of evidence. This latter

data is collected as a part of the groundwater monitoring program developed to support the natural attenuation remedy.

Optional lines of evidence - In certain cases, it may be necessary to develop additional lines of evidence to support the occurrence of natural attenuation particularly when the first and second lines of evidence are inconclusive. Examples of optional lines of evidence include solute transport modeling, microbiological studies, and estimates of assimilative capacity. Similar to secondary lines of evidence, once a demonstration of natural attenuations occurrence has been made through optional lines of evidence, the owner and operator should continue to collect information to support the primary line of evidence. When considering preparing optional lines of evidence for support of a natural attenuation remedy, concurrence should be received from DOH prior to initiating such efforts.

4. Performance Monitoring

Monitoring of the groundwater plume needs to be performed to assess that the plume is decreasing in both size and contaminant concentration over time. It is preferred that groundwater monitoring wells be placed 1) upgradient of the plume to monitor background water quality; 2) at appropriate locations to determine the horizontal and vertical extent of the plume boundaries;[1] 3) immediately downgradient of the plume to detect contaminant migration; and if required, 4) at a compliance point upgradient of any potential receptors to provide early detection of contamination before the receptors are reached. The monitoring well locations and elevations should be surveyed to allow the determination of groundwater flow direction and hydraulic gradient. DOH prefers a historic data collection of hydraulic gradient and groundwater flow direction be recorded throughout the life of the monitoring process. Downgradient monitoring of the plume can be discontinued when it can be demonstrated to DOH that groundwater monitoring indicates that contaminated groundwater is not likely to further migrate offsite and impact groundwater extraction wells or bodies of surface water at greater than Tier 1 action levels (i.e., the plume is stabilized). Monitoring of wells within the body of groundwater that exceeds Tier 1 action levels should, however, be continued until contaminant levels drop below the action levels for two successive seasonal cycles (generally successive years).

---

[1] The groundwater plume boundary would be defined as that point where groundwater contaminant concentrations are less than DOH RBCA Tier 1 Action Levels for groundwater.

5. Contingency Plan

A contingency plan should be developed that would be implemented if performance monitoring indicates that natural attenuation is not meeting remedial performance goals developed for the natural attenuation remedy. Criteria and thresholds should be developed which would measure the success of monitored natural attenuation with respect to plume migration control, receptor protection, and groundwater cleanup goals. If performance monitoring data indicate that criteria thresholds have been exceeded, then the monitored natural attenuation remedy would be reevaluated and the contingency measures considered for implementation.

6. Comparison to Other Remedial Options

A comparison of monitored natural attenuation to other methods of remediation should be done to compare the cost and length of time for completion of groundwater remediation. Cleanup of groundwater using monitored natural attenuation should occur within a period of time which is reasonable considering current and future groundwater use impacted or potentially impacted by the release.

In conclusion, DOH believes that where a supportable demonstration can be made as to its effectiveness, monitored natural attenuation can be an appropriate component of a broader remedial approach, or in some cases, as an effective standalone remedy for petroleum hydrocarbon releases. When it can be demonstrated that natural attenuation has successfully reduced the hydrocarbon contaminant concentrations within the groundwater contaminant plume to below DOH RBCA Tier 1 action levels, DOH would then consider the remediation of groundwater to be complete.

APPROVED/~~DISAPPROVE~~D

Bruce Anderson, Ph.D., Deputy Director, Environmental Health
Department of Health

Oct. 23, 1998
Date